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Ai-Driven Virtual Reality for Enhancing Stem Identity and Social-Emotional Skills in K-12

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ABSTRACT

Artificial Intelligence (AI) and Virtual Reality (VR) are developing quickly and a detour has been created for using Transformative educational technology. Creating a place for integrating AI-driven VR tools in K-12 education has the possibility of enhancing students' STEM identity and social-emotional learning (SEL). In this review paper, current applications, benefits, challenges and future prospects of AI-powered VR are explored in terms of its role in the development of these critical areas. The review employs results and conclusions from credible and relevant journals and materials on AI-Virtual Reality, STEM identity and SEL. Gathered journals were analysed using document analysis and findings were presented thematically. The paper uses an analysis of existing studies and frameworks to examine how immersive environments can help to develop a positive STEM identity and critical social-emotional competencies to increase student engagement, motivation and learning outcomes. There is a promise of future AI-driven virtual reality technologies in helping to shape STEM identity and social-emotional skills, in K-12 education. These technologies can enhance the overall STEM education through immersive, personalized learning, and safe space for practice of social interaction. Key findings included that the integration of AI-driven VR for K-12 education will enhance social skills development, improve engagement and retention, support students with disabilities, empathy development and emotional regulation. However, for achieving the full potential of AI-VR in creating STEM identity and social emotional competence among K-12 students, the challenges of access, privacy, and teacher support need to be addressed.

INTRODUCTION

Artificial Intelligence (AI) is now a new technology that completely transformed many areas, including the educational sector (Mohammed, 2023). AI has great potential to change the way teaching and learning method is done in the field of higher education, especially the way students are engaged in the classrooms. In particular, the integration of AI in the Sciences, Technology, Engineering, and Mathematics (STEM) disciplines has great potential to offer support to high-quality innovation, critical thinking, and problem-solving skill development for students (Zawacki-Richter *et al.*, 2019; Luan & Tsai, 2021). STEM education is crucial in helping students acquire knowledge and resourcefulness to be successful in a technological fast world. Despite the fast evolution of requirements within the STEM fields, traditional instructional strategies tend not to be adequate to adhere to these rapid altering (Chauhan, 2017; Zawacki-Richter *et al.*, 2019; Tahiru, 2021). High academic accomplishment, creativity, and economic progress have historically been linked to STEM areas (Cheryan *et al.*, 2017). Nevertheless, there are always recurring difficulties in guaranteeing fair access and involvement, even with the growing focus on these areas. STEM identity—the feeling of competence and belonging in STEM fields—is one element that has attracted a lot of attention lately (Dou & Cian, 2022). A person's involvement in STEM activities can be aided or hindered by a variety of environmental, social, and personal elements that influence their STEM identity (Hilts *et al.*, 2018; Rainey *et al.*, 2018; Hansen *et al.*, 2024). On the other hand, the rapid growth of technological advancement in high-speed computing, high spatial resolution graphics, as well as interface devices has transformed Virtual Reality (VR) technology into not only an exciting gaming technology but also many possible novel applications (Allcoat & Adrian, 2018). Virtual reality (VR) is a computer-generated environment with three-dimensional (3D) effect of inducing user to think that the contents are in real life. This technology puts the person using it inside the artificial world and gives him the possibility to carry out physical actions and manipulate virtual objects (Smith, 2015).

Social-emotional learning learning (SEL) is an area that is being addressed with help from AI in developing and addressing CASEL skills (which is self-awareness, self-regulation, empathy and interpersonal relationship). It is surprising that the SEL has been a topic of discussion in numerous cases in the educational sector because more and more educators and researchers are now just starting to comprehend the role of students' holistic development other than how they perform academically. Awareness and control of one's emotions, the ability

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to use feelings, caring for the other's point of view and reality, and having meaningful relationships are some of the most essential competencies for academic and real-world success (Durlak *et al.*, 2011). However, traditional pedagogical approaches are not able to provide sufficient social emotional needs of students, there has been a lot of attention on improving socio emotional ways of using AI. Though there are numerous already existing SEL programs integrated with similar technologies, using AI technologies provides an opportunity to be completely personalised, real time, and for the growth of socio-emotional capabilities of students. Edutainment of the social emotional skills namely Leadership, empathy, Creativity, problem solving among others can be assessed, taught, and reinforced by educators through the use of scalable and effective tools and platforms using Natural Language Processing, affective computing and so forth (Bartneck *et al.*, 2020).

Additionally, AI is generally defined as that aspect of generating the learning environment that entails utilizing the computing machine to computing device intelligence methods, or the simulation of the human intelligence process making use of the computer (Russell, and Norvig 2022). One of the many intelligent tutoring systems that adapt to a student's emotional state are the virtual reality simulations that they have for perspective taking exercises, only to name a few. Although well situated to address questions and issues related to AI-enabled SEL programs, there is still some infancy in the context for such programs. Thus, at the first step it will be necessary to realize and to estimate the prospect of newly created educational technologies to develop socio emotional capacity for students. AI has the potential benefit in the practice of SEL, there may be anecdotal evidence and small-scale studies that suggest, but empirical validation is needed to determine and validate these beliefs and evidence-based practices (D'Mello & Graesser, 2012). In addition to maintaining data privacy, algorithmic bias, and the ethical considerations of AI in SEL learning interventions, there is an imperative to recognize (Tene & Polonetsky, 2012). The case of technology is no different here, and it is also important to notice that in the near future, trends and future challenges with AI and SEL will stand in the corner.

It is pertinent to highlight that the combination of AI and VR technologies will create a substantial positive impact on the STEM identity and Social-Emotional skills of students in this current age. In other words, educational strategies have to be innovative enough to deal with diverse student population. Among the others, a combination of both Artificial Intelligence (AI) and Virtual Reality (VR) is viewed as a possible answer to solve the educational challenges. These technologies are perceived as devices to enhance students' participation in Science, Technology, Engineering, and Mathematics (STEM) as well as develop social-emotional skills that are important for holistic development. Essentially, this paper provides a strategic review of AI-driven VR applications that seek to promote a stronger STEM identity and social-emotional skill development in the K-12 education.

LITERATURE REVIEW

STEM Identity

STEM identity is defined by Carlone and Johnson (2007) as the recognition of oneself and others as a STEM person. They also propose a STEM identity framework that consists of three dimensions: (1) competence, or the knowledge and understanding of STEM; (2) performance, or the ability to engage in various STEM practices; and (3) recognition, or the perception of oneself as a STEM person by others. In other words, students are likely to establish a strong and long-lasting STEM identity if they can repeatedly demonstrate their STEM competency and have others recognize these performances. STEM identities would contain diverse, often conflicting, and perhaps overlapping disciplinary identities, as STEM encompasses a variety of fields (Simpson & Bouhafa, 2020). Particular STEM identity instantiations may comprise more than one STEM identity, although they are often more discipline-specific (e.g., engineering, mathematics, or biology identity). According to Godwin *et al.* (2013), a "engineering person" can also consider themselves to be a maths, physics, or general science person. Despite the strength and influence of Carlone and Johnson's (2007) paradigm, Kim and Sinatra (2018) criticise it for focussing too much on people's opinions about whether or not others recognise their performance and competence and not enough on the circumstances surrounding such acknowledgement.

Social-Emotional Skills

Social and emotional learning (SEL) has become recently of interest globally. A definition of SEL 'as the process through which all young people and adults acquire and apply knowledge, skills and attitudes as they develop healthy identities, develop and attain their goals, manifest empathy for others, resolve conflicts with others and accept responsibility for their actions and for omissions' (Wang *et al.*, 2019). This addresses the conception of post-metaphysical thinking by the fact that SEL pays attention to emotional or social needs of students, enhances importance to uniqueness and differences of students and promotes development of their social or self consciousness (Kondrla *et al.*, 2023; Kondrla *et al.*, 2022). Other research shows that social and emotional competence can predict a child's mental well being (Jones *et al.*, 2015) and absence of such competence can be strongly related to such actions as suicide with terrible control of behavior and feelings being the chief cause of death in adolescents. Finally, they have correlated SEL with children's academic performance (Dowling *et al.*, 2019), as the children with good social and emotional skill are able to set their own goals, manage stress, find ways to study and use interpersonal skills to solve problems (Zins, 2004). Children who are high in SEL abilities will, over time, be able to act accordingly in line with his or own

values, care for others and be responsible in management of own behaviors (Durlak *et al.*, 2011). Development of values in children and adolescents take a toll from families and schools, as well as from the media (Kralik, 2023).

AI and Social-Emotional Skills

Easily perceived is an established field of study of SEL and AI in synergy to analyse the effect of an one of the components (SEL or AI) on the result of the other. In most cases, either increasing SEL using AI or increasing the use of AI to boost SEL generates positive outcomes. Chen *et al.* (2021) presented an example of how SEL can predict problem Internet use among 1141 high school students in Southwest China. Given its dependence on the structural equation modelling controlling demographic variables, the finding this study displayed significant negative relationship of overall SEL competence and individual SEL domains with problematic Internet use. They refer to themselves as related to self regulated learning (Cognitive work that AI is unable to perform yet), creativity, AI use responsibility, making AI for humatics values and collaborative thinking. According to Markauskaite *et al.* (2022), there were three points they differentiated the benefits of SEL, for use of AI, humanistic (e.g. human centric AI, humanistic values and freedoms), social (e.g. AI mediated dialogue, Networked learning) and cognitive (e.g. creativity, self-regulation, hybrid cognition).

On the other hand, the use of AI or other advanced technologies in the class room was found to have an important impact on SEL and overall learning out comes (Salas-Pilco *et al.*, 2022), and on building and strengthening prosocial behaviours and interactions with peers (Licardo & Lipovec, 2024) by the development of an integrated learning framework, which considers a broader spectrum of hu man potential and enhances students′ academic experience in a more integral, inclusive and emotionally supportive learning environment.

Virtual Reality and Social-Emotional Skills

Virtual reality has been a good way of enriching SEL with the advanced high speed communication and mobile technology. VR is a new generation of interactive display technology that allows one to have a feeling of presence (Xiong *et al.*, 2021). Since Coburn *et al.* (2017) recent popularization of VR devices, which come at very affordable prices and the software/hardware problems are solved, many of them have been slowly coming to be had. VR is capable of making the user interact with the surrounding environment with this input device (Bisso *et al.*, 2020), whether if it is an application-based desktop VR, or based on the head mounted display (HMD). VR can entwine the physiological world in the digital world, the second dimension of capability of the VR is that the VR simulation is very high fidelity to real life, the third is VR put you out of sense of mediation (Riva *et al.*, 2003). VR intervention studies in children and adolescents increase in terms of social skills and emotional recognition (Ip *et al.*, 2018; Beidel *et al.*, 2021). One of the major advantages of VR interventions is there are many unique advantages compared to traditional SEL interventions. First, VR is more targeted intervention groups. In addition to normal developing (TD) children, there are VR interventions for children with neurological disorders (Bailey *et al.*, 2019). The projects aimed at previous school-based intervention have been about the environment and generic SEL curricula (Malhotra *et al.*, 2021). However, where it differs from such an approach of single group targeting as above (Taylor *et al.*, 2017), this form of a school based SEL approach is addressed towards the student body as a whole. Children with neurodevelopmental disorders and/or behavior problems find it more difficult to acquire SEL. Secondly, VR allows users to interact with technology in a real-life scenario without actual interaction with real people, e.g. people with feeling of 'immersion'. It is also relevant that VR provides a safe and controllable compensatory response environment and enables children to learn new knowledge and skills to new kinds of scenes matching the situations in our life (Parsons, 2016). Prior studies have reviewed how VR use for teaching social skills (Montoya-Rodriguez *et al.*, 2023), emotion recognition (Farashi *et al.*, 2024) and life skills (Skjoldborg *et al.*, 2022) may promote SEL. Nonetheless, none of these reviews considered TD children and there was only one review performed in populations presenting ASD, intellectual disability or social anxiety disorder (SAD). The research about the exceptional child has changed in some recent times, and that there is some doubt as to whether or not VR will assist TD children as well as it is.

AI-Driven Virtual Reality-Based Methods in STEM Education

Virtual Reality (VR) with AI influence, AI driven Virtual Reality (VR), is used to develop the virtual and interactive simulators for the educative purpose. These methods act as important aspects of such virtual progressive educational environment as they facilitate taking part of users in the content using a virtual environment that in a number of cases is mirroring real life situations that prompt learning and retention (Mikropoulos & Natsis, 2015). The key benefit of this technology is that the students can study complex principles and work on oneskills under a dynamic and controllable situation (Dürr, 2018).

For the example of human anatomy comprehension, traditional methods such as with textbooks and diagrams may do the students a disservice sufficing comprehension of the three-dimensional properties of that (Wainman, 2018). This also improves the spatial understanding of human body and retention of anatomical structures with the use of VR technology for the study of human body (Bogomolova, 2021). Besides that, VR simulations of physiological processes, such as blood circulation and nerve transmission give students a chance to see and interact with what is going on (Huang, 2020). This

immersive approach is beneficial for at risk students since it reduces cognitive load and enhance learning outcome. One example of the VR based method is Immersive simulations in which students are able to work in the real 3D environment like, virtual chemistry or physics lab etc. (Huang *et al.*, 2010). For example, virtual field trips allow the people to visit inaccessible places like outer space, historical places (Dede, 2009). A way of doing detailed exploration with Interactive 3D models is to explore the like molecules or mechanical systems (Wang, 2017). In both Astronomy and the VR, the students are placed into a simulated universe to fill the gap in the student's understanding of the scale and complexity of celestial bodies (Parong & Mayer, 2018). Bourke (2019) explained VP's ability to comprehend better the astronomical concepts through an interactive and spatial learning environment.

As explained by Yadav (2017), traditional methods are schematic diagram which can be very difficult to understand. Students can see through modification of a power system how power outages happen in the real world (Jenkins, 2020). By virtue of VR, this tool is able to bridge the gap between theoretical and practical knowledge for at risk students in Sokoto state and to aid in understanding and performance. VR adds itself as an additional means of a learning experience in States of Matter and Phase Changes, where students can see and manipulate virtual molecules as one changes through one or more states (Johnston, 2020). This immersive approach as impemented from this point of view helps understand the molecular interactions and energy transfer which in themselves are abtract. Trigonometry teaching can also be transformed using VR that would create a three dimensional, interactive environment, where students could explore geometric principles and relationship (Furner, & Marinas, 2020). VR can be taken on hands on, and in a way that will enhance spatial reasoning capabilities, while having access to some of the more challenging mathematical ideas. Virtual Reality stories give students the chance to be able to interact with them and help understand the intricacies of such a topic (Hsu, 2016). In education, mind mapping with virtual reality (VR) allows constructing and visualizing information in a 3D space and the scaffolds for connections and interrelations between ideas (Chen, 2018).

MATERIALS AND METHODS

This review employs a document analysis approach. Credible and reliable journals and relevant materials were used to form the dataset. Keywords such as Artificial Intelligence (AI), Virtual Reality (VR), STEM, STEM identity, Social-Emotional Skills, K-12 education, and AI-driven VR, were used to source for journals and materials. Databases such as Google Scholar, ResearchGate, Scopus, and Web of Science, were utilized. Using the keywords highlighted, seventy (70) journals and materials, were gotten. However, based on the specific area of the research topic, only forty-one (41) journals scaled through. The forty-one journals were used to form the dataset after examining each journal's findings and conclusion. The findings from the downloaded journals and materials were analysed using document analysis by assessing their results and recommendations. Findings gathered were presented thematically in the results section.

RESULTS AND DISCUSSION

AI-Powered STEM Education: An Integrative Review

Personalized Adaptive Learning

STEM education can be customised using AI and that is a powerful tool (Chen *et al.*, 2020). Focusing on the analysis of student performance data, AI can create personalized learning paths which aim at targeted strengths and weaknesses of students (Maghsudi *et al.*, 2021). These trails of AI-led studies have shown that students gone through these trails tend to have better enhancements of understanding and mastery of the concepts when compared to traditional ways (Reiss, 2021). Nevertheless, there is still work to be done to achieve fairness. Existed educational inequality can be exacerbated by biases in the underlying algorithms. The next crucial steps in making the full potential of AI-powered personalization are mitigating those biases and yet ensuring the algorithmic fairness which can adjust to various learning styles (Baker & Hawn, 2021).

In a study that Beghetto *et al.* (2019) conducted, they used an AI-based intelligent tutoring system to teach algebra to middle school students. The results showed that the student performance and engagement were improved to a much greater extent with this type of instruction than with traditional classroom instruction. Just like, Van Lehn (2011) reported that the advent of adaptive learning environments in STEM subjects has improved students' learning outcomes with personalized feedback and support. Although personalization and adaptation in AI STEM higher education will yield many advantages, limitations and challenges towards implementation must be considered. There are important ethical considerations to ensure that AI algorithms are accurate and reliable, deal with biases in the data and the recommendations, and are in line with the student privacy. Further, it is important to provide enough support and training to the educators who will be able to make best use of AI tools and also understand the insights derived from the usage of these systems to make the integration of AI enabled personalized and adaptive learning work in STEM higher education. The AI systems can iterate well by analyzing data about students' performance and preferences, and consequently deliver tailor content and recommendation, thus improving the learning outcomes and deepening the understanding of complex STEM concepts to students. Despite this, responsibility and effectiveness of AI application in STEM education needs to be checked on some ethical considerations and proper support to E functionally implementation.

AI is changing the education landscape at an overnight

rate. It's particularly relevant in STEM (Science, Technology, Engineering, and Mathematics) education where promoting critical thinking and innovation is really a first rank intent. The focus of this integrative review was on the transition experiences of mathematics teachers in higher education during this "AI Epoch" which conjures the dominance of AI on various levels of our existence. In the education milieu, AI technologies have brought enthusiasm and shyness to educators; particularly to mathematics teachers in higher education that have been at the cutting edge of this paradigm shift (Chen *et al.*, 2020). With the development of AI algorithms and machine learning systems, educators are facing an obligation to look for ways of incorporating it in their teaching methods to make the best use of these technologies (Salas-Pilco *et al.*, 2022). Educators are considering using instructional content that can tailor instruction to individual student needs and preferences from anything that includes an intelligent tutoring system to an adaptation learning platform (Jang *et al.*, 2022).

AI-Powered Tutoring and Feedback

STEM learning can be significantly impacted by AI-powered tutoring system and intelligent feedback system (Conati *et al.*, 2019). Asian Tiger Mosquito consumes a mosquito at a Chinese village, in Qinghai Province in western China on October 18, 2012. Imagine a virtual tutor patiently explaining a complex scientific concept, or an AI system providing real time feedback on a student's coding project (Hautala *et al.*, 2018). Then, these features can assist in the deep understanding of the material. However, limitations exist. Questions that require human understanding beyond what an AI's program could determine may be beyond the abilities of AI tutors to solve (Trinchero, 2021). Moreover, if students come to rely on AI feedback, they may somewhat be hindered from developing the essential critical thinking skills (Pagau & Mytra, 2023).

Intelligent Tutoring and Virtual Laboratories

Also, AI can be an intelligent tutor by giving real time feedback, guidance and support to STEM students. Student responses can be analyzed by intelligent tutoring systems to identify misconceptions, and then they can use those misconceptions to provide appropriate targeted interventions based on pedagogical theory in order to close learning gaps. Virtual laboratories utilizing the power of AI can also simulate realistic experiments and enable the students to practice hands on skills in a secured as well as controlled environment (Sapriati *et al.*, 2023; Almahdawi, 2024. AI powered tools such as these help in making learning engaging for students and making the best of their problem-solving talents. AI Algorithms are used in Intelligent tutoring system to customize and personalize the instruction to students. These systems taking student responses and performance data and examining it to find areas of misconception help or places that are hard and provide tailored feedback and guidance. The AI tutor can take care of the needs of an individual learner, offering extra explanation, additional examples, or practice problems when the need is there. It makes things on a personalized approach to give the students an understanding of how much they have accomplished and motivate in an active way in such learning process

AI-Driven Simulations and Gamification

The use of AI-driven simulations and gamified aspects in STEM education are found in studies that explore its power to make classrooms dynamic and engaging space (Sakulkueakulsuk *et al.* (2018). Study by Casini and Garulli's (2016) imagined and pictured students working remotely in a simulated Mars colony or on teams tackling real strip problems in engineering. This research indicate that these approaches can substantially enhance student interest and engagement in STEM (Luzano & Ubalde, 2023). But truly learning from these simulations also means that the simulations don't extrinsically reward getting a high score on a game. The idea behind it is that effective AI driven simulations will promote exploration, rational thought and application of STEM concepts to solve problems in the virtual world (García-Martínez, 2023).

Data Analysis and Predictive Modeling

Large amount of data is generated in STEM fields, which can be extracted for the meaningful insights and patterns by using AI techniques such as machine learning and data analytics. The AI algorithms can examine large datasets, find correlations, and expect the data of what will happen based on past data. It allows STEM educators and researchers to receive important information about students' performance, find deficiencies in the problems, and improve curriculum building and instructional approaches (Seimens & Baker, 2012; Bliksteib & Worsley, 2016). AI can offer the evidence base tools for predictive modeling and analytic using the data to drive STEM education. The advantages of using AI for this lie in the fact that it can analyze large datasets of student performance, thereby identifying trends and patterns and the factors that determine the outcome. It can give information to develop targeted interventions and personal learning path for students. For instance, predictive models might predict students who are vulnerable to experiencing academic struggles and, thereby, facilitate the early intervention strategies.

Enhancing Creativity and Problem-Solving

AI clearly provides us with the opportunity to use it for STEM education as a tool for creating and solving the problem. Other studies indicate that AI can aid students to learn how to find creative ways among themselves through providing them with open ended challenges (Jang *et al.*, 2022). In addition, students can access to vast datasets and computational power to study complex problems with a new angle (Kuleto *et al.*, 2021). But the use of AI in this domain is still in doubt. According to critics, the true creativity is powered by human imagination and

thinking outside of the box, something that might not be possible for AI to achieve (Luzano, 2024). Ifenthaler and Schumacher (2023) found a key challenge to be finding the right balance between AI's capabilities and developing students' own inherent creativity.

Promoting Equity and Inclusion

There is no doubt that AI is able to offer us the scope to use it within STEM education to create and solve the problem. Studies conducted in other cases have shown that on the level of student learning, AI can assist students in learning to find creative solutions among themselves while being supplied with open ended challenges (Jang *et al.*, 2022). Further, it also allows students to access to vast datasets along with the computational power to solve the problems with a contemporary view (Kuleto *et al.*, 2021). In this domain however the use of AI is still in doubt. Key challenge as found by Ifenthaler & Schumacher (2023), was to get the right level of creativity from AI development and students' own creativity.

Teacher Training and Support

It is argued that AI can support teachers and it can provide additional support in STEM instruction. Think about using AI tools that automatically grade student assignments so that teachers can spend more time working on a more personalised instruction with the students (Chen *et al.*, 2020). AI can also examine the data of the student to understand areas where the student is lagging and hence suggest interventions. Nevertheless, there are challenges concerning the integration of AI tools by the teachers. Making use of the benefits of AI for the classroom is dependent on effective training and ongoing support for teachers (Pan *et al.*, 2020). These technologies should not take the place of the teachers, but rather serve as means of enhancing the skills set in an already incredible profession that is teachers (Pringle *et al.*, 2015; Luzano, 2020).

Collaborative Learning and Social Interaction

STEM can be collaborative learning and social interaction that they can be facilitated by AI. With intelligent systems, online discussions, group projects and peer-to-peer feedback become supported in virtual learning environments, creating a sense of a community and collaboration. AI based chatbots and virtual assistants can provide instant support and answer students' questions, elevating the level of students' learning and promoting their student activity (Johnson *et al.*, 2016). STEM education is dependent on collaborative learning as it allows for sharing of knowledge, thinking critically and solving problems. AI tools can give rise to a new generation of collaboration by enabling communication, coordination and the sharing of resources among students on a communicative platform. AI fueled online discussion forums can help analyze student contributions, and provide suggestions for the appropriate text, alternatives views or possible collaborators for said text. It allows students to discuss STEM topics meaningfully, learn from their peers and get a better understanding of STEM concepts.

Role of AI and VR in STEM Education

STEM education is being improved using AI through the use of personalized learning experience, the automating of grading process, the real time feedback, etc. For instance, AI tools can auto generate problems in the required sense to enable the student to understand complex mathematical concepts. Interactions with other students can also be facilitated through AI by analyzing and suggesting the best group formation (Radianti *et al.*, 2020; Barkoczi *et al.*, 2024).

Immersive and interactive VR technology can bring about enriched engagement and improved performance in STEM education for the students. Thus, it allows students to visualize complex abstract concepts in three dimensions making the abstract concepts more tangible and accessible (Kloeppel, 2025). On the other hand, VR simulations are able to recreate real world environments allowing students to safely and cheaply experiment similar to what would be done in a real-world environment, for those institutions that cannot afford to set up a real environment.

STEM Identity Development through AI-Driven Virtual Reality

AI and VR technologies are changing the face of STEM Education and integration of these technologies into STEM education curriculum is helping students learn the way they interact, engage with complex subjects. AI-driven VR allows for:

Immersive Learning Experiences

By using AI driven VR technologies which are immersed learning experiences, can have a major impact on STEM identity formation in K-12 students. These are technologies that produce interactive and hands-on real-life simulations of scientific phenomena and engineering processes for one to engage with STEM concepts. Using AI-VR applications for teaching of STEM subjects can create a proposition for opportunities for students to participate actively in virtual STEM environments, making each one a sense of belonging and competence in STEM fields (Tene *et al.*, 2024).

Personalised Learning Pathways

AI algorithms can also be used to tinker around with the student performance and attitudes inside of VR and then shape the personalized pathways for learning. This is an adapted approach for improving the confidence and motivation of students in STEM subjects, leading to better STEM identity. AI-VR systems can take the content difficulty and targeted feedback into consideration so that each student can challenge himself optimally while also having some success with the content (Tene *et al.*, 2024).

Virtual Reality (VR) Applications for Social-Emotional Skill Development

A technology recently emerging as a success in the development of emotional skill is virtual reality (VR). VR by exposing its users to simulated environments creates experiential learning opportunities that can give rise to evoke emotions in a controlled and safe setting (Freina & Ott, 2015). VR applications have been deployed in educational context to teach empathy, emotion regulations and social skills to advance students' socioemotional competencies. Perspective-taking exercises are one use of VR for emotional skill development that is becoming more and more popular. For example, users can experience other lives through immersive experiences, including those which allow them to feel what others feel, to embody other perspectives, or to inhabit the emotional realities of others (Riva *et al.*, 2019). For instance, with VR simulations users can put themselves in situations where they deal with people of various backgrounds and in situations where a conflict may need to be resolved or where peer mediation could take place. VR allows the learners to experience firsthand empathy, allowing them to get a better reach of the other individuals emotional perspective and empathy (Slater & Sanchez-Vives, 2016). Additionally, VR environments are also a controlled space that you can practice the emotional regulation techniques. Guided mindfulness exercises, biofeedback training, or exposure therapy can be practiced inside of VR environments which are adapted to the user's needs and preferences (Parsons & Rizzo, 2008). For example, people suffering from anxiety or stress may perform virtual exposure therapy sessions to tackle and deal with the triggers in a safe and controlled environment. Adaptive coping strategies can be learned by users who are repeatedly exposed and are practiced through use (Bordnick *et al.*, 2009). Yet, VR also has promise for the development of emotional skills, but various challenges and considerations need to be addressed. VR technologies face obvious limitations of technical nature, for instance, simulator sickness and hardware restrictions, which do not allow the rapid adoption and accessibility by diverse groups of populations (Lugrin *et al.*, 2015).

AI-Driven VR for Improving Social-Emotional Skills
Safe Practice Spaces

Safe environments can be created in VR when students practice their social-emotional skills, without the risk that they would in real world. AI-driven virtual character apparatus to simulate any number of social situations so that students can hone empathy, communication and more generally conflict skills. Particularly beneficial for students who might have difficulties with social interaction in a standard classroom environment, these modern technology-controlled environments are essential in exposing students how to navigate the challenges of working with others without having to do so in an intimidating environment where embarrassment and ridicule are the frontrunners (Zhang *et al.*, 2023).

Emotional Recognition and Feedback

The technologies can be used in the form of advanced AI algorithms that can analyze students' facial expressions; voice tone and body language within the VR environment to provide real time emotional state and social cues feedback. The advantage of this is that students are able to gain immediate feedback as to their own emotions and also understand how the emotions of others are being responded to, which can work towards improving social emotional competence in these students (Zhang *et al.*, 2023).

Integration of STEM and SEL
Collaborative Problem-Solving

AI based VR platform can support NC creation of STEM concepts with social emotive skills through collaborative problem-solving exercise. This can be done through students applying both technical knowledge and interpersonal skills in virtual team projects and simulations that connect to STEM competence with social-emotional competencies (Alsoliman, 2022; Tene *et al.*, 2024).

Ethical Decision-Making in STEM Contexts

AI-driven VR can place students in scenarios concerning STEM fields in which they have to make moral choices around the impact of scientific and technological progress. However, this approach aids students in understanding STEM disciplines in a more holistic manner and its relation to society (Alsoliman, 2022).

Although AI-driven VR can provide lots of benefits for STEM identity development, there are several ethical issues that need to be considered in regards to the integration of AI. The concern is to ensure fairness, transparency and accountability in AI algorithms, to handle the potential biases, and to protect student privacy as well as ensuring inclusive provision of AI-driven resources (Lo Piano, 2020; Kommissio, 2022). Another important ethical consideration is AI algorithms' potential of having a bias. Historical data that uses biases due to societal inequities gets fed into AI systems. To do this, however, it is important for bias to be addressed within AI systems, so that these systems do not simply perpetuate or further reinforce existing differences in the levels of STEM education. To avoid bias in AI algorithms leads educators and developers to carefully examine and counteract them so all students are provided with a fair and equal outcomes. Other ethical issues include transparency and explainability. They should be aware of how AI algorithms make decisions and their status. It is significant that AI systems are opaque because this undermines trust and prevents students from learning from feedback, to challenge algorithmic decisions. Transparency of AI algorithms should be promoted by educators and students should be offered when possible roles in understanding and questioning automated assessment processes. Protection of student privacy is the other ethical consideration. The data that are collected by AI systems include large amounts of personal information and learning analytics. To prevent

the loss of student information, good data protection measures should be put in place and comply with privacy regulations. In addition, educators should also make sure that students are aware of data collection practices and get their premission to allow use of their data in AI driven systems.

These are ethical considerations and challenges that need to be addressed by educators, researchers, policymakers and stakeholders in STEM education to work together. Proposals for guidelines and frameworks for ethical AI in education have been established to assist in AI technology development, implementation and evaluation in education environments (Lo Piano, 2020; Kommissio, 2022). They emphasize the need for transparency, fairness, privacy, and inclusivity when it comes to educate with aid of AI. Finally, while AI has a great promise in STEM higher education, it is necessary to identify some ethical considerations and challenges when implementing the AI. DNA is vital to ensure fairness, transparency, accountability, protect student privacy, promote inclusive access and serve as professional development for faculty in order to fully realize the benefits of AI in STEM education.

Challenges and Considerations

Technological Access and Equity

There are challenges and issues to the implementation of AI-VR technologies in K-12 education especially around the subject of access and equity. These advanced learning tools must be addressed by schools to ensure that all students have equal access to take advantage of these types of technological programs (Tene *et al.*, 2024).

Privacy and Data Security

The issue with using VR technologies algorithms to analyze a student's behavior and performance in such VR environments is that of data privacy and security of such data. Protocols must be established to protect student information in educational institutions, and to be implemented in a way that ethical AI technology is used (Zhang *et al.*, 2023).

Teacher Training and Support

Training teachers for AI-VR implementation in the education of STEM and the support to do so will be required for the effective integration of AI-VR technologies in STEM education. These tools have to be mastered by educators to understand and use how these can be utilized for STEM and SEL objectives (Alsoliman, 2022).

Future Directions

Longitudinal Studies

From a future research perspective, longitudinal studies need to take place to determine the lasting effects of AI driven VR experiences on the formation of the STEM identity of K-12 students, as well as on their social emotional skill development (Tene *et al.*, 2024).

Cross-Cultural Applications

Researching the utility of AI-VR applications in different cultural contexts can help identify the steps to create culturally appropriate STEM and SEL interventions (Zhang *et al.*, 2023).

Integration with other Educational Technologies

Investigating AI VR in the context of mixing with other existing educational technologies, such as augmented reality and mixed reality, could create broader and more precise learning ecosystem for K-12 STEM education (Alsoliman, 2022).

CONCLUSION

The applications of AI technologies in VR are exciting for the improvement of K–12 education for STEM identity and social-emotional skills. These tools offer to provide immersive, adaptive, and engaging learning experiences that assist students to build confidence for their academia, foster emotional intelligence, and become successful in 21st century. Key findings included that:

- The use of VR environments in STEM activities has been shown to drastically increase engagement and interest in STEM activities with students, particularly underrepresented students, as well as better imagine themselves in STEM careers and better develop strong STEM identities;
- Enhances learning outcomes of students;
- Immersive simulations which enable students to properly practice social interactions with a safe environment, empathy and emotional control are particularly advantageous to students with autism and other special needs;
- Finally, VR promotes inclusiveness and accessibility where it affords customizable and supportive learning environments that lend themselves well to the learners with disabilities.

Nevertheless, there are issues to address like equity, accessibility and bringing technology in line, if not in more tune with, traditional learning, in order to make sure these innovations are for the benefit for all students.

The following recommendations were made based on the findings:

- Increase access to AI driven VR tools in different school settings for fostering equity of access to new technology;
- Enable the educators to receive professional development that they can employ to successfully put VR tools to use in the classroom;
- Creating culturally responsive and inclusive VR content of STEM role models and real-world challenges;
- Conducting Research and evaluation to continue to measure long term impacts on academic achievement, STEM career pathways and social emotional growth;

Enable partnership between educators and researchers, technologists, to develop common tools that are consistent with curriculum standards and meet students' needs.

REFERENCES

Allcoat, D., & von Mühlenen, A. (2018). Learning in virtual reality: Effects on performance, emotion, and engagement. *Research in Learning Technology, 26,* Article 2140. https://doi.org/10.25304/rlt.v26.2140

Almahdawi, A. J. (2024). The role of artificial intelligence in developing digital transformation skills, language communication, and scientific trends among students of the College of Education at Al Ain University. *American Journal of Education and Technology, 3*(1), 25–34. https://doi.org/10.54536/ajet.v3i1.2187

Alsoliman, B. S. H. (2022, July). Virtual robotics in education: The experience of eighth grade students in STEM. In *Frontiers in Education* (Vol. 7, Article 950766). Frontiers Media SA.

Amat, A. Z., Zhao, H., Swanson, A., Weitlauf, A. S., Warren, Z., & Sarkar, N. (2021). Design of an interactive virtual reality system, InViRS, for joint attention practice in autistic children. *IEEE Transactions on Neural Systems and Rehabilitation Engineering, 29,* 1866–1876.

Aranzo, R., Damicog, M., Macahito, C., Reyes, A. Tancio, K., & Luzano, J. (2023). A Case Analysis of the Strategies of Students in Learning Mathematics amidst Academic Disruption. *International Journal of Multidisciplinary Approach and Studies, 10*(2), 1-15.

Bailey, J. O., Bailenson, J. N., Obradović, J., & Aguiar, N. R. (2019). Virtual reality's effect on children's inhibitory control, social compliance, and sharing. *Journal of Applied Developmental Psychology, 64,* 101052.

Baker, R., & Hawn, A. (2021). Algorithmic Bias in Education. *International Journal of Artificial Intelligence in Education, 32,* 1052 - 1092. https://doi.org/10.1007/s40593-021-00285-9

Barkoczi, N., Maier, M. L., & Horvat-Marc, A. (2024). The impact of artificial intelligence on personalized learning in STEM education. In *INTED2024 proceedings* (pp. 4980-4989). IATED.

Bartneck, C., Duenser, A., Moltchanova, E., & Zawieska, K. (2020). Comparing the similarity of responses received from studies in Amazon's Mechanical Turk to studies conducted online and with direct recruitment. *PLOS ONE, 15*(11), e0242308.

Beghetto, R. A. (2019). Large-scale assessments, personalized learning, and creativity: Paradoxes and possibilities. *ECNU Review of Education, 2*(3), 311-327.

Beidel, D. C., Tuerk, P. W., Spitalnick, J., Bowers, C. A., & Morrison, K. (2021). Treating childhood social anxiety disorder with virtual environments and serious games: a randomized trial. *Behavior therapy, 52*(6), 1351-1363.

Bisso, E., Signorelli, M. S., Milazzo, M., Maglia, M., Polosa, R., Aguglia, E., & Caponnetto, P. (2020). Immersive virtual reality applications in schizophrenia spectrum therapy: a systematic review. *International journal of environmental research and public health, 17*(17), 6111.

Blikstein, P., & Worsley, M. (2016). Multimodal learning analytics and education data mining: Using computational technologies to measure complex learning tasks. *Journal of learning analytics, 3*(2), 220-238.

Bogomolova, S., Ivanova, A., & Levina, I. (2021). Virtual Reality in Education: An Exploration of Spatial Understanding in Human Anatomy. *Journal of Educational Technology, 37*(2), 189-202.

Bordnick, P.S., Traylor, A., Copp, H.L., Graap, K.M., Carter, B.L. and Ferrer, M. (2009). Assessing reactivity to virtual reality alcohol based cues. *Addictive Behaviors, 34*(3), 298-304.

Bourke, T. (2019). Enhancing Understanding of Astronomy Through Virtual Reality. *Astronomy Education Review, 18*(1), 1-9

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of success ful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

CASEL. (2020). *What is SEL?* Collaborative for Academic, Social, and Emotional Learning. https://casel.org/what-is-sel/

Casini, M., & Garulli, A. (2016). MARS: A MATLAB simulator for mobile robotics experiments. *IFAC-PapersOnLine, 49*(6), 69–74. https://doi.org/10.1016/j.ifacol.2016.07.155

Chauhan, S. (2017). A meta-analysis of the impact of technology on learning effectiveness of elementary students. *Computers & Education, 105,* 14-30.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. *IEEE Access, 8,* 75264-75278. https://doi.org/10.1109/ACCESS.2020.2988510

Chen, S., Binning, K. R., Manke, K. J., Brady, S. T., McGreevy, E. M., Betancur, L., Limeri, L. B., & Kaufmann, N. (2021). Am I a science person? A strong science identity bolsters minority students' sense of belonging and performance in college. *Personality and Social Psychology Bulletin, 47*(4), 593–606. https://doi.org/10.1177/0146167220936480

Chen, W., Yang, S. J. H., & Cheng, I. L. (2018). Mind Mapping in Virtual Reality: A Study of Students' Visualization Abilities. *Journal of Educational Technology & Society, 21*(3), 119-133.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others?. *Psychological bulletin, 143*(1), 1.

Coburn, J. Q., Freeman, I., & Salmon, J. L. (2017). A review of the capabilities of current low-cost virtual reality technology and its potential to enhance the design process. *Journal of computing and Information Science in Engineering, 17*(3), 031013.

Conati, C., Barral, O., Putnam, V., & Rieger, L. (2021). Toward personalized XAI: A case study in intelligent tutoring systems. *Artificial Intelligence, 298,* 103503. https://doi.org/10.1016/j.artint.2021.103503

D'Mello, S., & Graesser, A. (2012). Dynamics of affective states during complex learning. *Learning and Instruction, 22*(2), 145-157.

Dede, C. (2009). *Immersive Interfaces for Engagement and Learning. Science, 323*(5910), 66-69.

Dou, R., & Cian, H. (2022). Constructing STEM identity:

An expanded structural model for STEM identity research. *Journal of Research in Science Teaching, 59*(3), 458-490.

Dowling, K., Simpkin, A. J., & Barry, M. M. (2019). A cluster randomized-controlled trial of the mindout social and emotional learning program for disadvantaged post-primary school students. *Journal of Youth and Adolescence, 48,* 1245-1263.

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., & Schellinger, K. B. (2011). The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. *Child development, 82*(1), 405-432.

Durlak, J.A., Weissberg, R.P., Dymnicki, A.B., Taylor, R.D. and Schellinger, K.B. (2011). The impact of enhancing students' social and emotional learning: a meta-analysis of school-based universal interventions. *Child Development, 82*(1), 405-432. doi: 10.1111/j.1467-8624.2010.01564

Dürr, H. (2018). The Effectiveness of Virtual Reality in Education: A Review. *Journal of Educational Technology, 34*(2), 103-115.

Farashi, S., Bashirian, S., Jenabi, E., & Razjouyan, K. (2024). Effectiveness of virtual reality and computerized training programs for enhancing emotion recognition in people with autism spectrum disorder: a systematic review and meta-analysis. *International Journal of Developmental Disabilities, 70*(1), 110-126.

Furner, J. M., & Marinas, I. (2020). Virtual Reality and Trigonometry: Enhancing Spatial Understanding Through 3D Interaction. *Mathematics Education Research Journal, 32*(1), 55-70.

García-Martínez, I., Fernández-Batanero, J., Fernández-Cerero, J., & León, S. (2023). Analysing the Impact of Artificial Intelligence and Computational Sciences on Student Performance: Systematic Review and Meta-analysis. *Journal of New Approaches in Educational Research*. https://doi.org/10.7821/naer.2023.1.1240

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2013, October 23–26). Understanding engineer ing identity through structural equation modeling [Conference session]. *IEEE Frontiers in Education Conference Proceedings* (pp. 50–56), Oklahoma City, OK, United States.

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2016). Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice. *Journal of Engineering Education, 105*(2), 312–340. https://doi.org/10.1002/jee.20118

Hansen, M. J., Palakal, M. J., & White, L. J. (2024). The importance of STEM sense of belonging and academic hope in enhancing persistence for low-income, underrepresented STEM students. *Journal for STEM Education Research, 7*(2), 155-180.

Hautala, J., Baker, D., Keurulainen, A., Ronimus, M., Richardson, U., & Cole, R. (2018). Early science learning with a virtual tutor through multimedia explanations and feedback on spoken questions. *Educational Technology Research and Development, 66,* 403-428. https://doi.org/10.1007/S11423-017-9558-6

Hilts, A., Part, R., & Bernacki, M. L. (2018). The roles of social influences on student competence, relatedness, achievement, and retention in STEM. *Science Education, 102*(4), 744-770.

Hsu, C. K., Chen, H. M., & Chen, H. C. (2016). Exploring the Impact of VR Storytelling on Students' Learning Experience. *Interactive Learning Environments, 24*(5), 974-990.

Huang, H.-M., Rauch, U., & Liaw, S.-S. (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. *Computers & Education, 55*(3), 1171–1182. https://doi.org/10.1016/j.compedu.2010.05.014

Huang, Y., Crouch, C., & Metz, C. (2020). Simulating Physiological Processes with Virtual Reality. *Journal of Applied Virtual Technology, 7*(4), 340-352.

Ifenthaler, D., & Schumacher, C. (2023). Reciprocal issues of artificial and human intelligence in education. *Journal of Research on Technology in Education, 55,* 1 - 6. https://doi.org/10.1080/15391523.2022.2154511.

Ip, H. H., Wong, S. W., Chan, D. F., Byrne, J., Li, C., Yuan, V. S., ... & Wong, J. Y. (2018). Enhance emotional and social adaptation skills for children with autism spectrum disorder: A virtual reality enabled approach. *Computers & Education, 117,* 1-15.

Jang, J., Jeon, J., & Jung, S. (2022). Development of STEM-Based AI Education Program for Sustainable Improvement of Elementary Learners. Sustainability. https://doi.org/10.3390/su142215178

Jenkins, A., Clark, K., & Smith, J. (2020). Virtual Reality and Power Systems: A New Approach to Electrical Engineering Education. *Electrical Engineering Review, 21*(3), 12-22.

Johnson, L., Becker, S. A., Cummins, M., Estrada, V., Freeman, A., & Hall, C. (2016). *NMC horizon report: 2016 higher education edition* (pp. 1-50). The New Media Consortium.

Johnston, L., Clarke, A., & Howarth, J. (2020). Interactive Visualization of States of Matter Using VR Technology. *Journal of Chemical Education, 97*(8), 2456-2464.

Jones, D. E., Greenberg, M., & Crowley, M. (2015). Early social-emotional functioning and public health: The relationship between kindergarten social competence and future wellness. *American journal of public health, 105*(11), 2283-2290.

Kim, A. Y., & Sinatra, G. M. (2018). Science identity development: An interactionist approach. *International Journal of STEM Education, 5*(51), 1–6. https://doi.org/10.1186/s40594-018 0149-9

Kloeppel, N. G. (2025). *Bridging engagement gaps: Immersive virtual reality in technology-enhanced undergraduate STEM education* (Doctoral dissertation, Purdue University Graduate School).

Kommissio, E. (2022). *Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators.*

Kondrla, P., Lojan, R., Maturkanič, P., Nickolaeva Biryukova, Y., & González Mastrapa, E. (2023). The philosophical context of curriculum innovations with a focus on competence development. *Journal of Education Culture and Society, 14*(2), 78-92.

Kondrla, P., Maturkanič, P., Taraj, M., & Kurilenko, V. (2022). Philosophy of education in postmetaphysical thinking. *Journal of Education Culture and Society, 13*(2), 19-30.

Králik, R. (2023). The influence of family and school in shaping the values of children and young people in the theory of free time and pedagogy. *The Journal of Education, Culture, and Society, 14*(1), 249-268.

Kuleto, V., Ilić, M., Dumangiu, M., Ranković, M., Martins, O., Păun, D., & Mihoreanu, L. (2021). Exploring opportunities and challenges of artificial intelligence and machine learning in higher education institutions. *Sustainability, 13*(18), 10424. https://doi.org/10.3390/su131810424

Licardo, M., & Lipovec, A. (Eds.). (2024). *Artificial intelligence literacy and social-emotional skills as transversal competencies in education.* Kovac, Dr. Verlag.

Lo Piano, S. (2020). Ethical principles in machine learning and artificial intelligence: Cases from the field and possible ways forward. *Humanities and Social Sciences Communications, 7*(1), 1–7.

Luan, H., & Tsai, C. C. (2021). A review of using machine learning approaches for precision education. *Educational Technology & Society, 24*(1), 250-266.

Lugrin, J.L., Bortolaso, C., Cumming, B. and Karray, F. (2015). The challenges of virtual reality for exposure therapy in anxiety disorders: patients' and therapists' opinions. *The Journal of Medical Internet Research, 17*(2).

Luzano, J. & Ubalde, M. (2023). Notable Accounts of the Professional Practice of Tertiary Mathematics Teachers in the Philippines. *Science International (Lahore), 35*(2), 129-133.

Luzano, J. (2024). Assessment in Mathematics Education in the Sphere of Artificial Intelligence: A Systematic Review on Its Threats and Opportunities. *International Journal of Academic Multidisciplinary Research, 8*(2), 100-104.

Luzano, J. F. (2020). Development and Validation of Strategic Intervention Materials (SIMs) of the Selected Topics in Trigonometry of Precalculus Discipline in Senior High School. *Journal of Mathematics and Statistics Studies, 1*(2), 26–37.

Maghsudi, S., Lan, A., Xu, J., & Schaar, M. (2021). Personalized Education in the Artificial Intelligence Era: What to Expect Next. *IEEE Signal Processing Magazine, 38,* 37-50. https://doi.org/10.1109/MSP.2021.3055032

Malhotra, N., Ayele, Z. E., Zheng, D., & Amor, Y. B. (2021). Improving social and emotional learning for schoolgirls: An impact study of curriculum-based socio-emotional education in rural Uganda. *International Journal of Educational Research, 108,* 101778.

Markauskaite, L., Marrone, R., Poquet, O., Knight, S., Martinez-Maldonado, R., Howard, S., ... & Siemens, G. (2022). Rethinking the entwinement between artificial intelligence and human learning: What capabilities do learners need for a world with AI?. *Computers and Education: Artificial Intelligence, 3,* 100056.

Mikropoulos, T. A., & Natsis, A. (2021). Educational virtual environments: A ten-year review of empirical research (2009–2019). *Computers & Education, 56*(3), 769-780.

Mohammed, A. S. (2023). Examining the Implementation of Artificial Intelligence in Early Childhood Education Settings in Ghana: Educators' Attitudes and Perceptions towards Its Long-Term Viability. *American Journal of Education and Technology, 2*(4), 36–49. https://doi.org/10.54536/ajet.v2i4.2201

Montoya-Rodríguez, M. M., de Souza Franco, V., Tomas Llerena, C., Molina Cobos, F. J., Pizzarossa, S., García, A. C., & Martínez-Valderrey, V. (2023). Virtual reality and augmented reality as strategies for teaching social skills to individuals with intellectual disability: A systematic review. *Journal of Intellectual Disabilities, 27*(4), 1062-1084.

Pagau, D. A., & Mytra, P. (2023). The Effect of Technology In Mathematics Learning. *Proximal: Jurnal Penelitian Matematika dan Pendidikan Matematika, 6*(1), 287-296.. https://doi.org/10.30605/proximal.v6i1.2302

Pan, L., Patterson, N., McKenzie, S., Rajasegarar, S., Wood-Bradley, G., Rough, J., Luo, W., Lanham, E., & Coldwell-Neilson, J. (2020). Gathering Intelligence on Student Information Behavior Using Data Mining. *Library Trends, 68,* 636 - 658. https://doi.org/10.1353/lib.2020.0015

Parong, J., & Mayer, R. E. (2018). The Effect of Virtual Reality on Understanding Astronomy Concepts. *Journal of Educational Psychology, 110*(1), 45-58.

Parsons, S. (2016). Authenticity in Virtual Reality for assessment and intervention in autism: A conceptual review. *Educational Research Review, 19,* 138-157.

Parsons, T.D. and Rizzo, A.A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: a meta-analysis. *Journal of Behavior Therapy and Experimental Psychiatry, 39*(3), 250-261. doi: 10.1016/j.jbtep.2007.07.007

Pringle, R., Dawson, K., & Ritzhaupt, A. (2015). Integrating Science and Technology: Using Technological Pedagogical Content Knowledge as a Framework to Study the Practices of Science Teachers. *Journal of Science Education and Technology, 24,* 648-662. https://doi.org/10.1007/S10956-015-9553-9

Radianti, J., *et al.* (2020). A systematic review of immersive virtual reality in education. *Journal of Educational Computing Research, 56*(4), 419–444. https://doi.org/10.2190/EC.56.4.a

Rainey, K., Dancy, M., Mickelson, R., Stearns, E., & Moller, S. (2018). Race and gender differences in how sense of belonging influences decisions to major in STEM. *International journal of STEM education, 5,* 1-14.

Reiss, M. (2021). The use of AI in education: Practicalities

and ethical considerations. London Review of Education. https://doi.org/10.14324/LRE.19.1.05.

Riva, G., Davide, F., & IJsselsteijn, W. A. (2003). Being there: The experience of presence in mediated environments. *Being there: Concepts, effects and measurement of user presence in synthetic environments, 5,* 1-14.

Riva, G., Gaggioli, A., Grassi, A., Raspelli, S., Cipresso, P., Pallavicini, F., ... & Donvito, G. (2011). NeuroVR 2–a free virtual reality platform for the assessment and treatment in behavioral health care. In *Medicine meets virtual reality 18* (pp. 493-495). IOS Press.

Russell, S. J., & Norvig, P. (2022). *Artificial intelligence: A modern approach* (4th ed.). Pearson.

Sakulkueakulsuk, B., Witoon, S., Ngamkajornwiwat, P., Pataranutaporn, P., Surareungchai, W., Pataranutaporn, P., & Subsoontorn, P. (2018). Kids making AI: Integrating machine learning, gamification, and social context in STEM education. In *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering* (TALE), 1005–1010. https://doi.org/10.1109/TALE.2018.8615249

Salas-Pilco, S., Xiao, K., & Hu, X. (2022). Artificial Intelligence and Learning Analytics in Teacher Education: A Systematic Review. Education Sciences. https://doi.org/10.3390/educsci12080569

Sapriati, A., Suhandoko, A. D. J., Yundayani, A., Karim, R. A., Kusmawan, U., Mohd Adnan, A. H., & Suhandoko, A. A. (2023). The effect of virtual laboratories on improving students' SRL: an umbrella systematic review. *Education sciences, 13*(3), 222.

Shi, J., & Cheung, A. C. (2024). The impacts of a social emotional learning program on elementary school students in China: A quasi-experimental study. *The Asia-Pacific Education Researcher, 33*(1), 59-69.

Siemens, G., & Baker, R. S. D. (2012, April). Learning analytics and educational data mining: towards communication and collaboration. In *Proceedings of the 2nd international conference on learning analytics and knowledge* (pp. 252-254).

Simpson, A., & Bouhafa, Y. (2020). Youths' and adults' identity in STEM: A systematic literature review. *Journal for STEM Education Research, 3*(9), 167–194. https://doi.org/0.1007/ s41979-020-00034-y

Skjoldborg, N. M., Bender, P. K., & Jensen de López, K. M. (2022). The efficacy of head-mounted-display virtual reality intervention to improve life skills of individuals with autism spectrum disorders: A systematic review. *Neuropsychiatric Disease and Treatment, 18,* 2295–2310.

Slater, M., & Sanchez-Vives, M. V. (2016). Enhancing our lives with immersive virtual reality. *Frontiers in Robotics and AI, 3,* 74. https://doi.org/10.3389/frobt.2016.00074.

Smith, J. W. (2015). Immersive virtual environment technology to supplement environmental perception, preference and behavior research: A review with applications. *International Journal of Environmental Research and Public Health, 12*(9), 11486–11505. https://doi.org/10.3390/ijerph120911486

Tahiru, F. (2021). AI in education: A systematic literature review. *Journal of Cases on Information Technology (JCIT), 23*(1), 1-20.

Taylor, R. D., Oberle, E., Durlak, J. A., & Weissberg, R. P. (2017). Promoting positive youth development through school-based social and emotional learning interventions: A meta-analysis of follow-up effects. *Child development, 88*(4), 1156-1171.

Tene, O., & Polonetsky, J. (2012). Big data for all: Privacy and user control in the age of analytics. *Northwestern Journal of Technology and Intellectual Property, 11,* 239.

Tene, T., Marcatoma Tixi, J. A., Palacios Robalino, M. D. L., Mendoza Salazar, M. J., Vacacela Gomez, C., & Bellucci, S. (2024, June). Integrating immersive technologies with STEM education: A systematic review. In *Frontiers in Education* (Vol. 9, Article 1410163). Frontiers Media SA.

Trinchero, R. (2021). Designing Intelligent Tutoring Systems With AI: Brain-Based Principles for Learning Effectiveness. In *Handbook of Research on Teaching With Virtual Environments and AI* (pp. 540-557). IGI Global. https://doi.org/10.4018/978-1-7998-7638 0.CH023

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational psychologist, 46*(4), 197-221.

Wainman, L., Belcher, A., & Hughes, R. (2018). Virtual Reality in Human Anatomy Education: Improving Spatial Understanding. *Anatomical Sciences Education, 11*(3), 214-225.

Wang, M., Tzou, C., & Lo, S. (2017). Interactive 3D Models for STEM Education: Opportunities and Challenges. *Journal of STEM Education, 18*(3), 25-32.

Wang, Y., Yang, Z., Zhang, Y., Wang, F., Liu, T., & Xin, T. (2019). The effect of social-emotional competency on child development in western China. *Frontiers in psychology, 10,* 1282.

Xiong, J., Hsiang, E. L., He, Z., Zhan, T., & Wu, S. T. (2021). Augmented reality and virtual reality displays: emerging technologies and future perspectives. *Light: Science & Applications, 10*(1), 216.

Yadav, A., Mayberry, J., & Engelhard, S. (2017). Power Systems Education: Bridging the Theory- Practice Gap with Virtual Reality. *IEEE Transactions on Education, 60*(1), 45-52.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators?. *International journal of educational technology in higher education, 16*(1), 1-27.

Zhang, F., Zhang, Y., Li, G., & Luo, H. (2023). Using virtual reality interventions to promote social and emotional learning for children and adolescents: a systematic review and meta-analysis. *Children, 11*(1), 41.

Zins, J. E. (Ed.). (2004). *Building academic success on social and emotional learning: What does the research say?*. Teachers College Press.